STATISTICAL ANALYSIS OF THE BRACHIOPOD GENUS STEGERHYNCHUS FROM THE WALDRON SHALE (SILURIAN) OF WALDRON, INDIANA

Presented in Partial Fulfillment of the Requirement for the degree Bachelor of Science

by

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Advisor Approval
Department of Geology and Mineralogy

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ABSTRACT

Five species representing Rhynchonella were described by Hall(1863) and by Beecher and Clarke(1889) as being represented in the Waldron shale of Middle Silurian age from the type locality at Waldron, Indiana. One species has since been removed from this genus and placed under the genus Ucinulus while the others have been placed under the genus Stegerhynchus. The purpose of the paper was to statistically analyze the four species under the genus Stegerhynchus and it has been shown that S. acinus is still valid as a species while S. neglecta, S. indianense and S. whitii should be grouped under the name S. neglecta since it was the first name of the three proposed.

PREVIOUS WORK

James Hall first described the fossils found at Waldron, Indiana, from the Waldron shale in Transactions of the Albany Institute in 1863. He described five species belonging to the genus Rhynchonella: R. neglecta (Hall), R. acinus Hall, R. indianense Hall, R. Whitii Hall, and R. Stricklandi Sowerby. He refers to the variation in the number of costae in the fold, sinus and latera but is not very specific as to their interspecific relations. His differentiation of R. neglecta from R. Whitii and R. indianense was "by its short form, and the fine sharp plications of the surface" which from a quantitative point of view is far from being desirable. If we now pay attention to Hall's descriptions of Rhynchonella species, we notice that there is a lack of any attempt to state specifically how these species can be differentiated from each other, other than by gross generalities which allow too much variénce. In respect to dimensions, he goes only as far as to occasionally state a measurement of the length or width, or state "length or width nearly equal, the width sometimes exceeding the length" which is almost totally worthless when one looks at the other species of Rhynchonella and notices that this is true of four of the five species. In contrast, he does much better in his reference to costae numbers on the shell(see Table 1), but they are still rather general as indicated in several of the following quotations taken from his report: R. neglecta-"...generally three and sometimes four plications in the sinus, and four or

five elevated on the opposite valve."; R. acinus-"...sinus..a single plication; three and rarely four plications on either side of the mesial fold...and four on each side of the sinus ...".

In Beecher and Clarke(1889), however, there is significantly much more information as to costae numbers and their relationships between the species, yet there are some difficulties. If we look at Table 1 which shows information given by Beecher and Clarke, we will note gaps where they have denoted no species name. Their classification of species is basically by number of latera except for the assignment of S. indianense, which is said to have four plications in the fold and three in the latera. The report fails to state how these assignments were made and little information is given on dimensions of shells although it gives an excellent report on the growth of the species. Your will also note that when one compares information given by Hall to that of Clarke and Beecher, there are a few discrepancies(see Table 1).

Costae in fold	Latera on brachial valve	Hall	Beecher and Clarke
2	3	R. acinus	R. acinus
2	4	R. acinus	R. indianense
2	5	R. whitii	
2	6	R. whitii	R. whitii
3	3		R. acinus
3	4	R. indianense ?	R. indianense
3	5		R. neglecta
3	6		
4	3	R. indianense?	R. indianense
4	4		R. indianense
4	5		R. neglecta
4	6		
5	4	R. neglecta?	R. indianense
5	5		

Table 1. Summary of Hall's and Beecher and Clarke's information on costae numbers.

WALDRON LOCALITY

The Waldron shale was first described by Hall in 1863 from a river cut exposure along Conn's Creek south of the town of Waldron, Indiana. It was discovered in 1860 by Professor David Christy, of Cincinnati, who in the Autumn of that year notified Hall of it. Today, the main exposure is in a quarry(NE¼ sec.6, T. 11 N., R. 8 E., Waldron Quad.) as seen in the maps in figures 1 and 2. For the last two or three years however, the quarry has not been worked and has been allowed to fill in with water, making collecting within the quarry impossible. However, there are several large dumps around the quarry as seen in the map in figure 2 where Waldron shale has slowly broken down revealing many fine fossils in excellent condition. It is from these dumps that during the summer of 1972 and the spring of 1973, I made a collection of approximately 1000 specimens of Stegerhynchus, of which 614 were found to be suitable for measurement and further study. As a note of interest, the shale is well known for its abundance of not only individuals but also its abundance of species. Hall(1863) described upwards of 175 different species while today well over 250 species have been described.

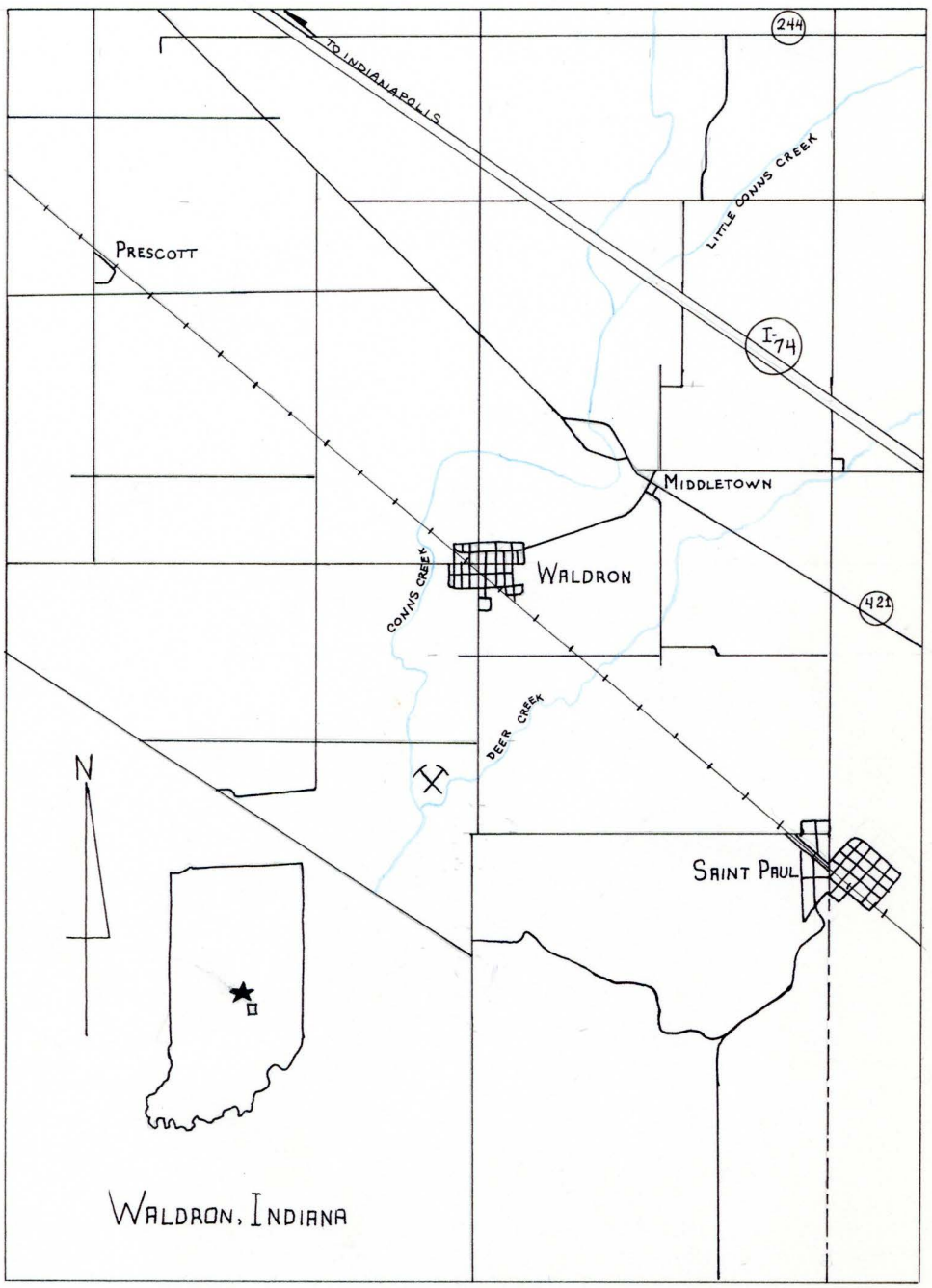

Figure 1. Map of the area around Waldron, Indiana.

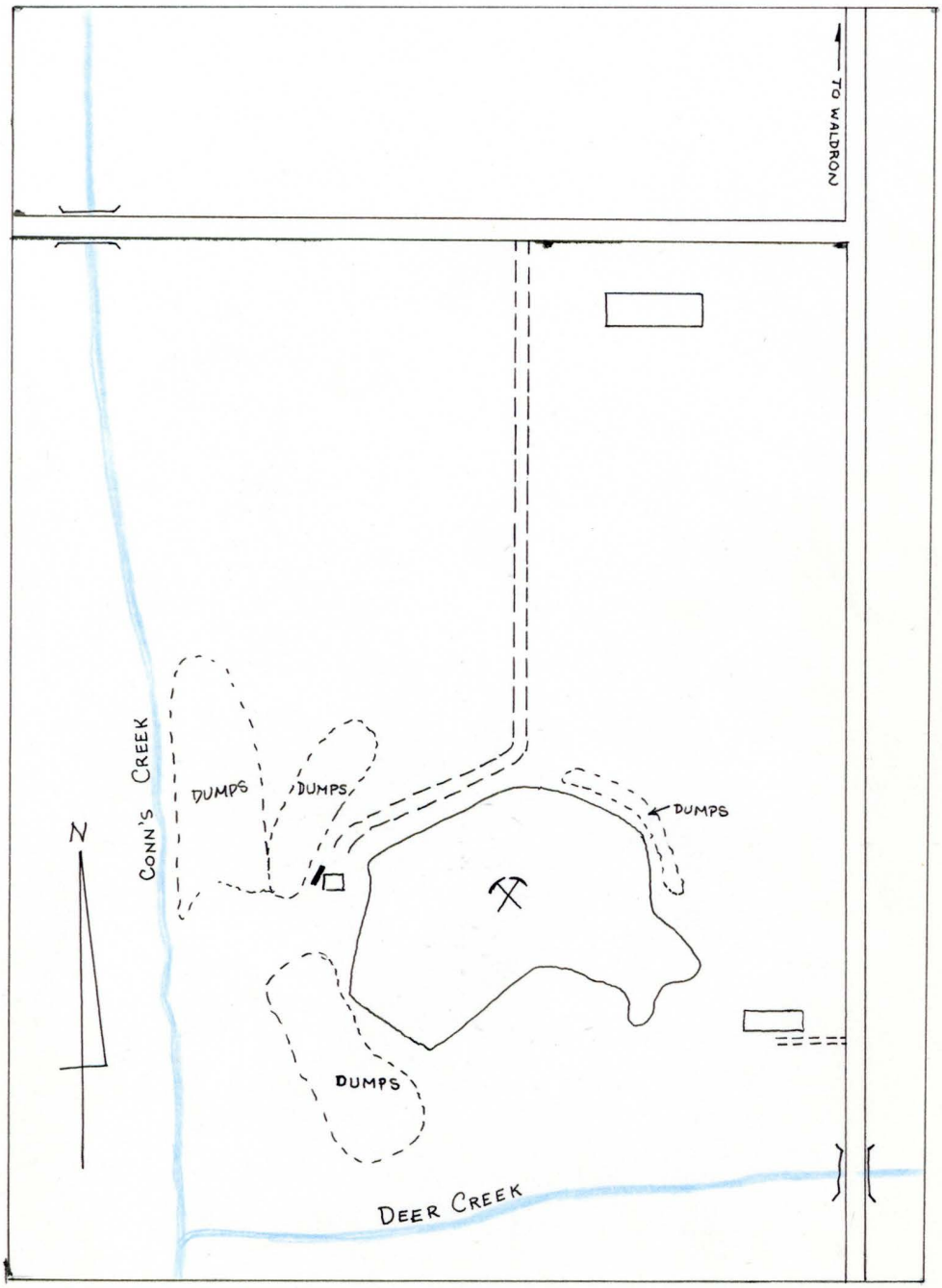

Figure 2. Map of the quarry at Waldron, Indiana.

GENERAL STRATIGRAPHY AND DISTRIBUTION OF THE WALDRON SHALE

The Waldron shale was named by Elrod in 1883 for Waldron, Indiana. It is generally thin, varies in thickness from a few inches to eight or nine feet, and is geographically very persistent. It is found in southern Indiana, Kentucky, central Tennessee and just into northern Alabama. Two major areas are the most fossiliferous: Waldron, Indiana, and Newsom, Tennessee. Otherwise few fossils are found. As for lithology, it is a gray or greenish-gray calcareous shale with a few laterally discontinuous thin beds of limestone. It lies between two very thick limestone units(see figure 3) which when compared lithologically are very similar. This suggests that the Waldron shale represents an interruption of this limestone deposition by an influx of silts and clays from some new erosional body.

At the Waldron Quarry, the Waldron is approximately 8.7 feet thick and is very fossiliferous whereas the overlying Louisville Limestone and the underlying Laurel Limestone are relatively unfossiliferous.

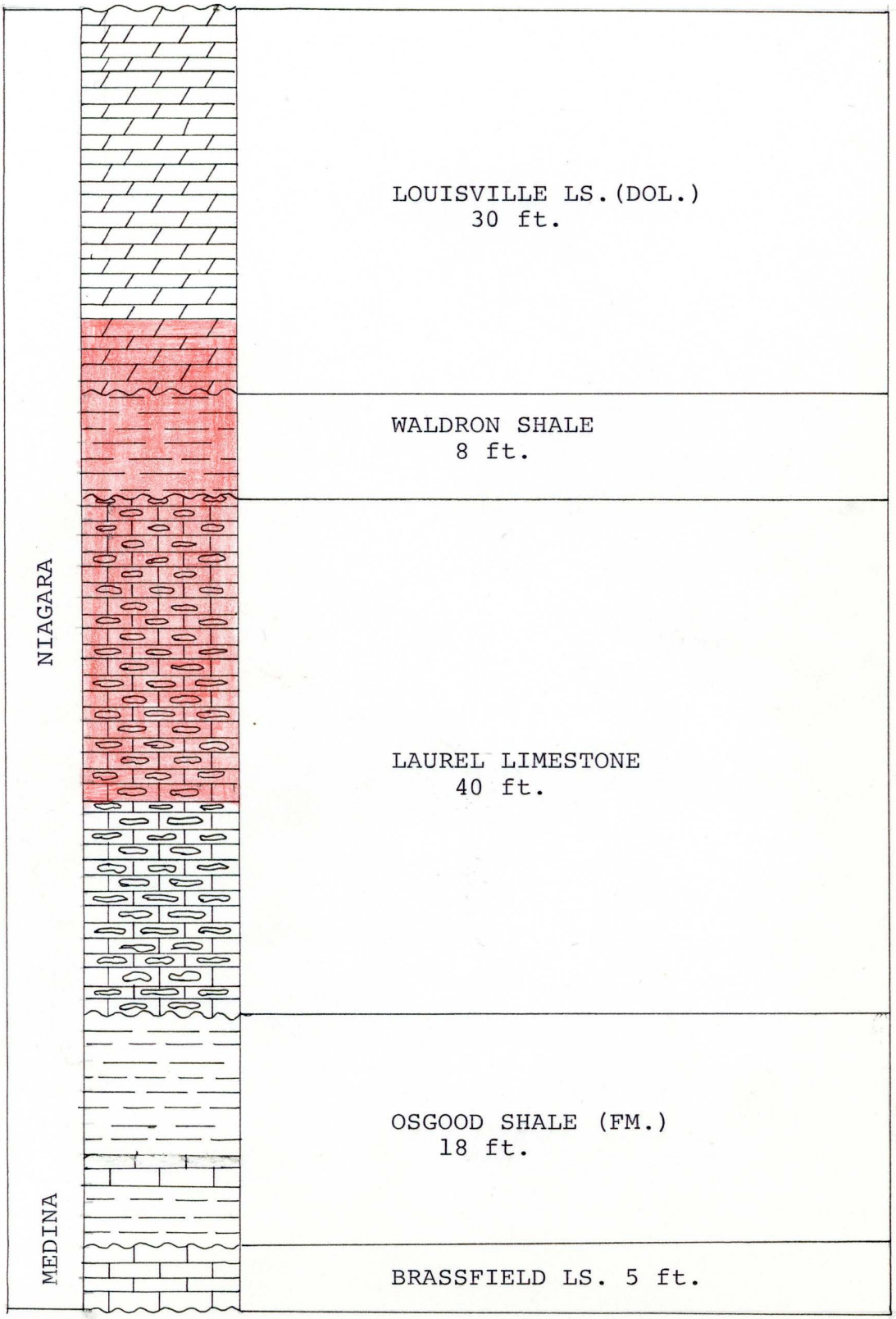

Figure 3. Stratigraphic column of Silurian in southern Indiana. Colored portion represents portion exposed in Waldron Quarry.

COLLECTION AND PREPARATION

Collecting was done from the dumps around the quarry which have been previously mentioned in the preceding section. Specimens were found predominantly whole while separate valves were very rarely found. Specimens were usually free from rock material and required little general cleaning although detailed cleaning between the costae was hampered or made impossible by pyritization. Pyrite also occurred in the form of cubes on the valves. A few as seen in figures 1 and 15 in plate 3, are almost completely silicified. Specimens shown in plate 3 represent each of the 15 groups and are shown primarily to acquaint the reader with the general appearance of the fossils. The author would like to apologize for the appearance of some of the fossils in the plate since some have been pyritized and cleaning was almost impossible. Some are represented by only a few specimens so it is difficult to show fine specimens.

DISCUSSION

The first step in the study of Stegerhynchus is to look for a morphological characteristic or set of characteristics which one can use to group the specimens and be, for the most part, certain that each group belongs to the same type. The obvious characters of Stegerhynchus are the costae which upon close inspection vary in number in both the fold and sinus, and the latera. For this study, 614 specimens have been used, from which 15 groups have been defined. In figure 5, the number of costae in the fold has been plotted against the number of specimens found. One sees a maximum number of specimens with two costae in the fold with a rapid downward trend in the number of specimens with an increase in the number of costae. Upon examination of figure 4, where number of costae in the latera of the brachial valve has been plotted against the number of specimens, one sees an approximation of a Gaussian distribution curve. This suggests that the number of lateral costae is a natural variation probably within a single species although this may not be the case. The great number of specimens with two costae in the fold compared with those with more seems to substantiate the idea that we are dealing with a single species rather than a group of four species as Hall and Beecher and Clarke have suggested.

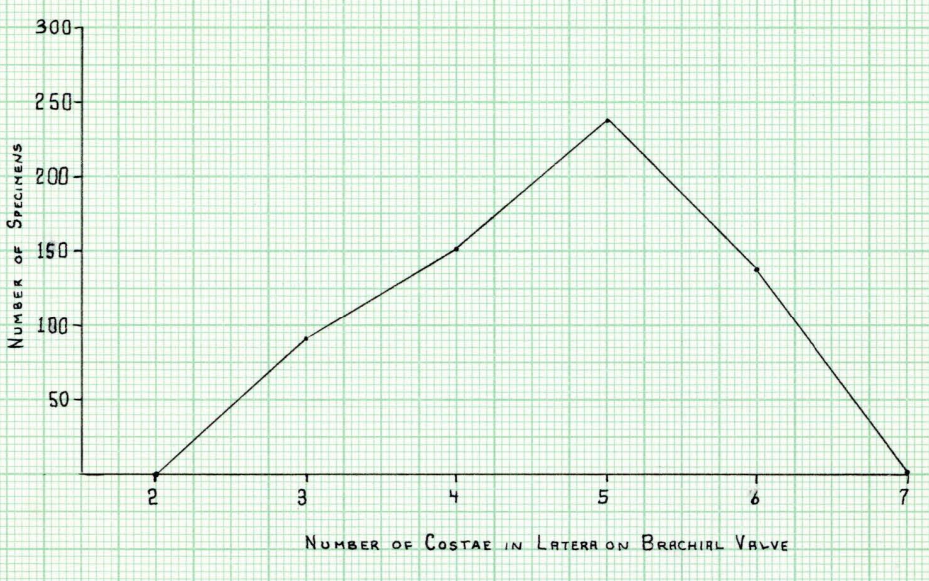

Figure 4. Costae in latera of brachial valve versus number of specimens.

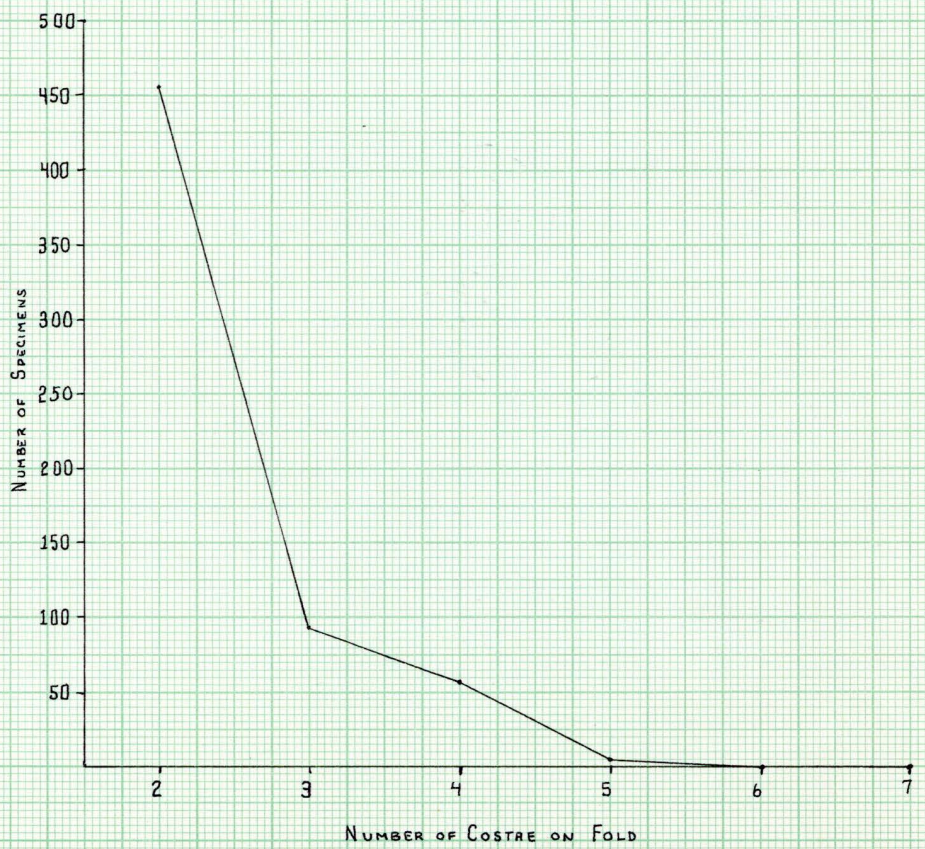

Figure 5. Costae in fold versus number of specimens.

10 Millimeters to the Centimeter

If this is the case, one should next compare another characteristic and see if this substantiates what we have hypothesized in the preceeding paragraph. Therefore, the next step was to take measurements of the length, width and thickness of each specimen(see figure 6) with particular note as to the group to which each specimen belonged. This was done with calipers and measured to the nearest tenth of a millimeter. One would then want to be able to plot the measurements or equivalents on a graph in order that relationships between the specimens should be fairly clear. Using a triangular graph, each specimen would be represented by a single dot utilizing all three measurements rather than one or two. Therefore, the three measurements of each specimen were added up and this divided into the individual measurements, thus obtaining a percentage for each dimension resulting in a sum of 100%. This could then be plotted on the graph. If we were dealing with an ideal case, one would end up after all the points had been plotted with a single point for each group and these corresponding with other points depending on the relationship of that group with the other. Therefore, if we are dealing with two species, the final graph would consist of two points on the graph. However, we are not dealing with an ideal case and the variation must be taken into account. Therefore, a standard deviation for each group

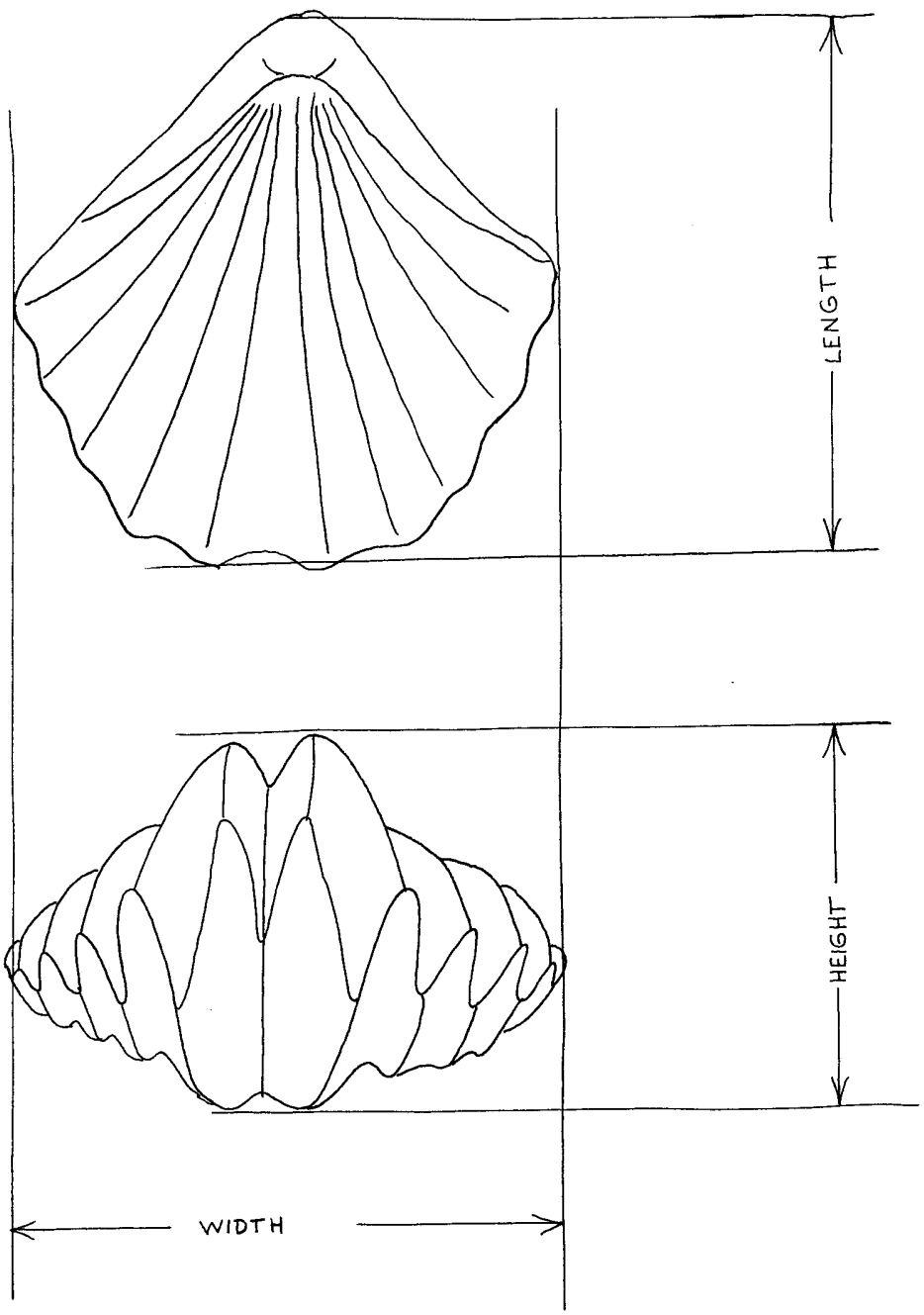

FIGURE 6. Diagram of method of measurements of Stegerhynchus.

should be found. This is obtained by first finding the mean of the points as given in the following formula:

$$\bar{A} = \sum A \; / \; N$$

where $\bar{A}$ is the mean, A is an individual value and N is the number of specimens used. This is done for the three percentages and the values recorded. These values for the groups are given in Table 2. The mean is then plotted on the graph and should lie close to the center of the cluster of dots for each group. The distance of each point in the group from the mean can be measured or the value can be found mathematically by the following formula:

$$D(\text{distance})^2 = \dot{A}^2 + \dot{B}^2 - 2 \cdot \dot{A} \cdot \dot{B} \cdot \cos 60^\circ$$

$\dot{A}$ and $\dot{B}$ are the differences between A and $\bar{A}$ and B and $\bar{B}$, respectively. The distance is left as a square since it saves a step in the next formula. The distances squared are then added together and divided by the number of specimens and the square root of this value is then determined, which gives the standard deviation. This can be represented mathematically as follows:

$$\sigma(\text{standard deviation}) = \sum D^2 \; / \; N$$

The standard deviation is useful in that when it is plotted on the graph it results in a circle around the mean with a radius equal to the standard deviation. Within this circle of one standard deviation radius, 68% of the group should be found. Within two standard deviations, 95.5% of the group

should lie and within three standard deviations 99.7% of the group should be found. This last circle, within which 99.7% of the group lies, should be good enough so that we are fairly certain that we have all of the specimens and therefore the maximum variation of each group. When this is done for each group we end up with figure 7. We can readily see that all of the circle lie in fairly close coincidence except for one that represents group 1. Therefore, it is reasonable to assume that those brachiopods representing group 1 are not of the same species as those of the other groups. Group 1 represents most of the group described by Hall and Beecher and Clarke as Stegerhynchus acinus and the other groups which represent formerly three separate species should now be denoted by a single species name which should be the oldest one described. This is Stegerhynchus neglecta first described as Atrypa neglecta Hall(1852).

Group	Costae in fold	Costae in latera	Number of specimens	Mean % Length	Width	Height	σ	$3 \cdot \sigma$
1	2	3	34	32.40	40.58	27.02	2.99	8.97
2	2	4	69	37.56	39.87	22.57	2.67	8.01
3	2	5	226	38.63	38.80	22.57	2.51	7.53
4	2	6	126	39.34	39.19	21.47	1.84	5.52
5	2	7	2	38.35	39.55	22.10	1.69	5.07
6	3	3	38	36.09	40.32	23.58	2.20	6.60
7	3	4	50	37.01	39.98	23.01	2.52	7.56
8	3	5	4	37.65	39.92	22.42	1.79	5.37
9	3	6	2	37.45	39.45	23.10	1.83	5.49
10	4	3	19	37.62	40.18	22.21	2.18	6.54
11	4	4	29	37.91	38.38	23.72	3.17	9.51
12	4	5	7	37.90	39.40	22.70	2.35	7.05
13	4	6	3	39.37	36.46	24.13	3.81	11.43
14	5	4	4	37.05	39.72	23.23	0.92	2.76
15	5	5	1	41.80	35.10	23.10	0.00	0.00

Table 2. Table of data from this study.

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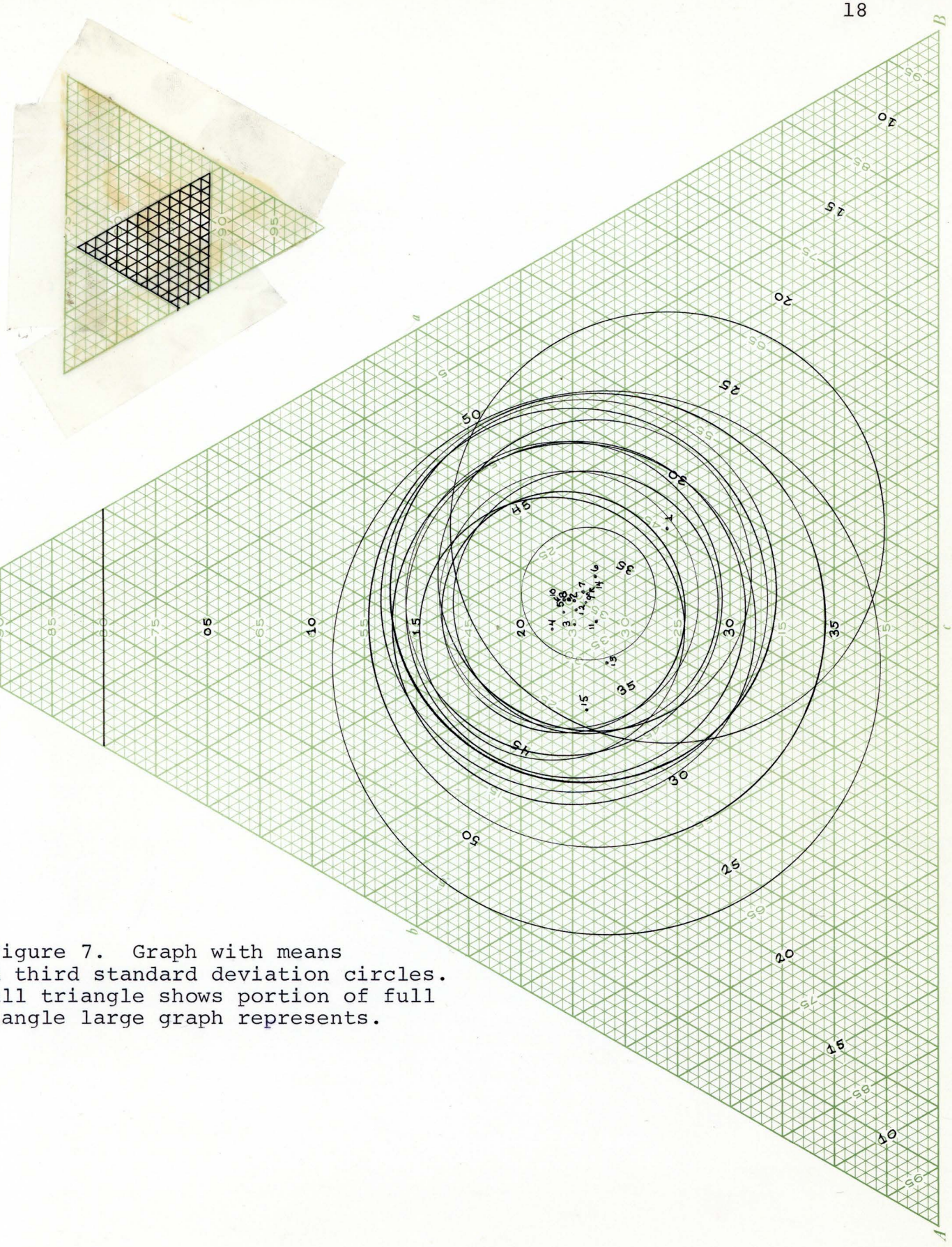

Figure 7. Graph with means and third standard deviation circles. Small triangle shows portion of full triangle large graph represents.

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PLATE 1

Figure 1. Waldron Quarry facing north. Water at lowest point since it filled up in 1971.

Figure 2. Waldron Quarry facing south showing Waldron Shale just above water line and overlying Louisville Limestone. Top of Laurel Limestone almost exactly coincides with water line.

PLATE 2

Figure 1. Waldron Quarry facing north. Taken during March of 1973 showing water completely overflowing quarry walls.

PLATE 3

All figures are brachial views with magnification of 3X.

Fig. 1 *Stegerhynchus acinus*-represents group 1 with two costae in the fold and 3 on either latera.

2 *S. neglecta*-represents group 2 with two costae in the fold and 4 on either latera.

3 *S. neglecta*-represents group 3 with two costae in the fold and 5 on either latera.

4 *S. neglecta*-represents group 4 with two costae in the fold and 6 on either latera.

5 *S. neglecta*-represents group 5 with two costae in the fold and 7 on either latera.

6 *S. neglecta*-represents group 6 with three costae in the fold and 3 on either latera.

7 *S. neglecta*-represents group 7 with three costae in the fold and 4 on either latera

8 *S. neglecta*-represents group 8 with three costae in the fold and 5 on either latera

9 *S. neglecta*-represents group 9 with three costae in the fold and 6 on either latera

10 *S. neglecta*-represents group 10 with four costae in the fold and 3 on either latera

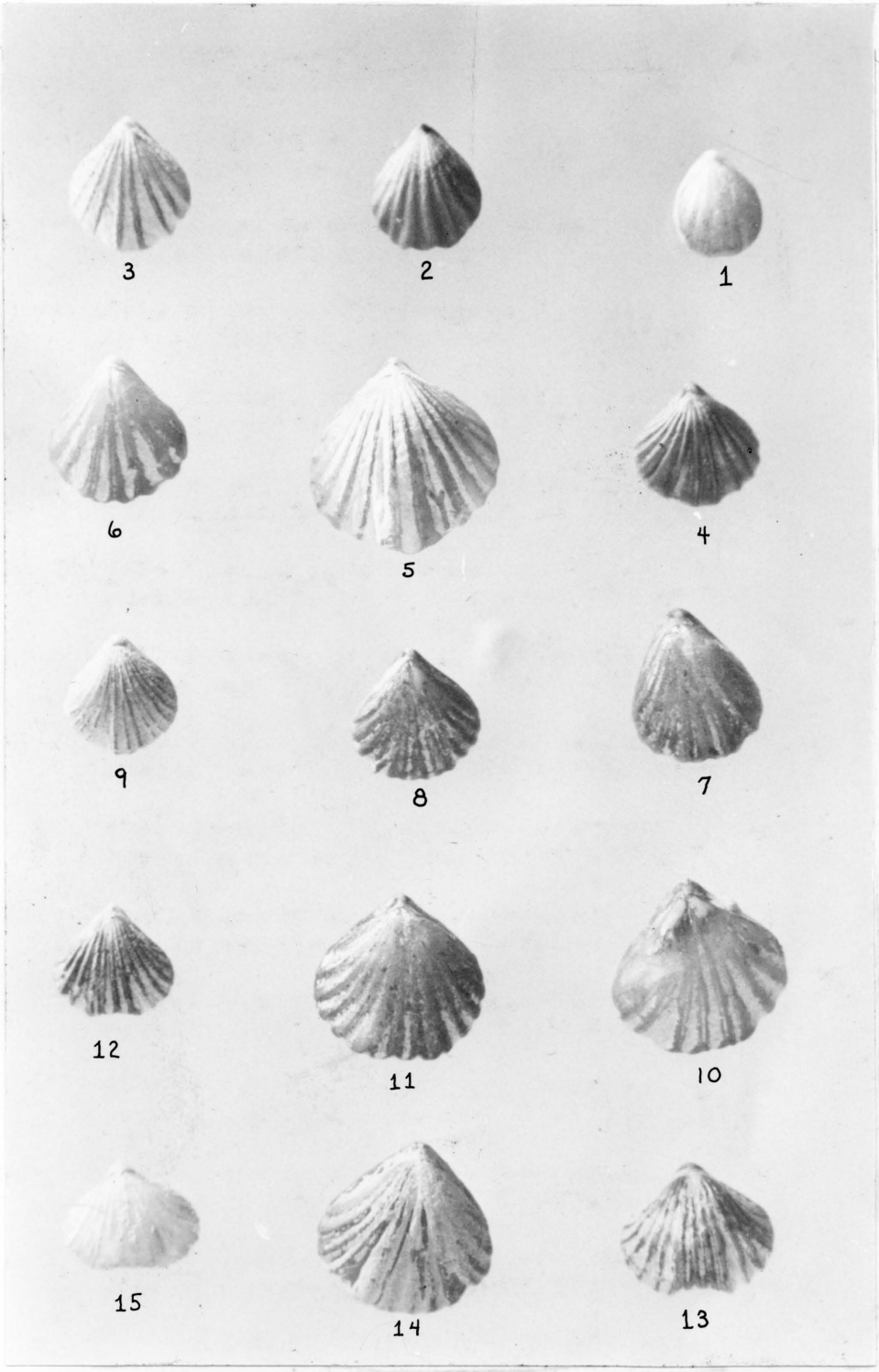
11 *S. neglecta*=represents group 11 with four costae in the fold and 4 on either latera

12 *S. neglecta*-represents group 12 with four costae in the fold and 5 on either latera

13 *S. neglecta*-represents group 13 with four costae in the fold and 6 on either latera

14 *S. neglecta*-represents group 14 with five costae in the fold and 4 on either latera

15 *S. neglecta*-represents group 15 with five costae in the fold and 5 on either latera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